"THE SWEEPER"
A unique method of determining SWR.   W9BTI June 1954

How many times have you VHF men wished that you had a SWR indicating device that would take over where most other SWR meters start to drop off and get inaccurate as the frequency is raised? The meter about to be described is just such a device. Its effectivness first starts at about 50 MC and gets better as the frequency rises. The SWR indicator described here was designed for the 2 meter band, but by increasing or decreasing the length of the tuned lines it can be adapted for "your band" be it 50, 144, 220, or 420 MC. It is essentialy a SWRM of the sweep oscillator and oscilloscope type. It has been suggested in literature* and is used by TV stations cable manufacturers etc. I have not to this date seen it described in any amateur publication so therefore I am passing it along to all those interested. Those that have used them praise them for their accuracy, simplicity of connection, ease of reading results and the ability to see directly the results of your adjustments on your antenna matching device. Since the device is basically a swept oscillator, it will be refered to from now on as "The Sweeper".

Before construction and application details are given, it might be wise to consider the theory of the sweepers operation. Consider the operation of a transmission line. When one end is terminated with a resistor that is non-reactive and is equal to the lines surge impedance, then the impedance seen at the other end will equal the surge impedance. This holds true for any radio frequency fed into the line. If the far end of the line is left open instead of having it terminated as above, then the impedance seen at the other end will depend on the length of the line and the frequency of the signal fed into it. As an example, a frequency which would make the unterminated line an even number of quarter wave lengths long would cause the impedance at the sending end to be very high. If this same unterminated line was fed a
frequency that made the line an odd
~~frequency that made the line an odd~~ number of quarter waves long, th-

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impedance seen at the sending end would be zero. If the same lines far end were shorted, then the results of the two examples above would be just the opposite, that is, in the first case the sending end would see a short and the second case it would see an infinitly high impedance. Frequencies occuring between these two extremes would cause the sending end to see a impedance varying from dead short to infinitly high. When the sweeper is attached to a line, and it sweeps over a range of frequencies, the impedance it sees will depend on what is connected to the other end of the line. If the line is terminated in the lines surge impedance the the sweeper sees a steady impedance equal to the surge impedance of the line, and will reproduce a straight line trace on the scope. But if the line is improperly terminated (a mismatch) then the impedance seen by the sweeper will vary with each frequency in the swept range. Since the frequency in the sweeper is being swept at a 60 cycle rate, the the impedance will vary at a 60 cycle rate. This changing impedance with its consequent varying voltage across it , is detected in the sweeper by a crystal diode. This voltage is 60 cycle AC with an RF component. After the RF if filtered out it is fed to the vertical amplifier of a scope. The scopes time base is also 60 cycles and is in phase with the sweeper so a sine wave trace appears on the screen. The amplitude of the sine wave indicates the degree of mismatch. So the object of your antenna adjustments is to reduce the sine wave amplitude to a straight line. I might add at this point that a fairly straight line can be easily obtained on a transmission line that is terminated in a carbon resistor of proper value and whose lead length is zero. However when the line is terminated in an antenna the task of getting a straight line is more difficult. There is a reason for not getting a pure straight line when it was terminated in a proper resistor in that there is no such thing as a perfect cable available commercially; but now with the antenna attached the load is frequency sensitive. You will note on the scope that

certain antennas can be made to produce a straight line over almost the entire screen whereas some are only flat for about one third of the screen. See diagram 1 J&I. This indicates the bandwidth of your antenna. Broadside arrays with few parasitic dipoles are quite flat and can be matched over the entire four MC sweep. However most high gain yagi's are very narrow in band width and show it on the scope. This fact must be borne in mind when using the sweeper so that you dont try to get some result that is theoretically impossible due to the type of antenna being adjusted. Let us say that the sweeper is attached properly to a 100 foot piece of RG8U, 52 ohm cable, and that the cable is properly terminated with a 52 ohm load, be it a resistor or antenna. The pattern on the scope will be a straight line as in the group of patterns of Fig 1 A. If the cables load is disconnected and left unterminated, the pattern at 1 B will result. If the cables load end is shorted then the same pattern will result but will have a 180 degree phase difference as in 1 C. If the 52 ohm cable is terminated, let us say with a 500 ohm resistor, a pattern as in 1 B will result. As the value of the resistor is reduced the sine wave pattern will gradually reduce in amplitude as in 1 D , which happens to be 100 ohms or a SWR of 2 to 1. As the resistor is brought near the cables surge impedance (52 ohms), the sine waves amplitude will reduce to zero and result in a straight line, as in 1 A. This is a SWR of 1 to 1. The number of sine waves that appear on the scope depends directly on the cable length. If the cable is to short, ie, if less than one half of a sine wave appears, then it would be advisable to add cable just for the test and remove the piece after you have made your antenna adjustments and have reduced your SWR. 100 feet is a very satisfactory length for 2 meters.

The frequency of a 955 oscillator tube is varied or sweptacross the band desired. The sweeper described is set up for the 2 meter band, so from now on dimensions refered to will be for the 2 meter band.

The sweep width can be set on a panel control from zero to 8 MC. The 2 meter band is 4MC wide so that will be all the sweep needed.

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However you may want to see how your SWR is out of the band so that is why 8 MC sweep width was included. The sweep control is a rheostat that adjusts the amount of 60 cycles AC voltage fed to the sweeper motor, which is from a surplus APN 1 altimeter receiver-transmitter. One quarter of a volt 60 cycles AC sweeps 4 MC.

Two circuits are included, the deluxe and the economy. Both do an excellent job and have equal accuracy. The deluxe circuit has a different scope presentation and enables you to check line losses, and is easier to interpret. The deluxe sweeper has a retrace blanking circuit built within. The circuit used actually stops the sweeping oscillator from oscillating when the sweep motor has reached its limit of excursion and is going to return and produce a retrace. The retrace is presented on the scope as a base line. The exact point where the oscillator is stopped and started is adjustable by means of the phase control included in the deluxe circuit. This adjustment is necessary to sync the action with the sweep motor and scope. The higher the line losses, the greater the distance between the base line and the negative excursion of the trace. If the line has zero lo (impossible), then the negative excursion willcoincide with the base line. A phasing control and an oscillator blanking switch is incorporated in the deluxe model to adjust for a correct scope pattern. On the economy circuit the pattern can be made clearer if the scope is equipped with retrace blanking and a phasing control.

The sweeper is equipped with a rough and a fine frequency control. The rough control is set so that the fine control adjusts the operating frequency only within the 2 meter band.

The output of the sweeper is terminated in two coaxial panel receptacl It is wise to make one the popular SO239, and the other a UG-58/U so as to make the instrument more versatile. On coax checking, attach the cable to the receptacle that fits its connector and cover the other unused fitting with a coax cover which has been modified to short the receptacle to groun with a low inductance path. Two covers will be necessary, each one with it

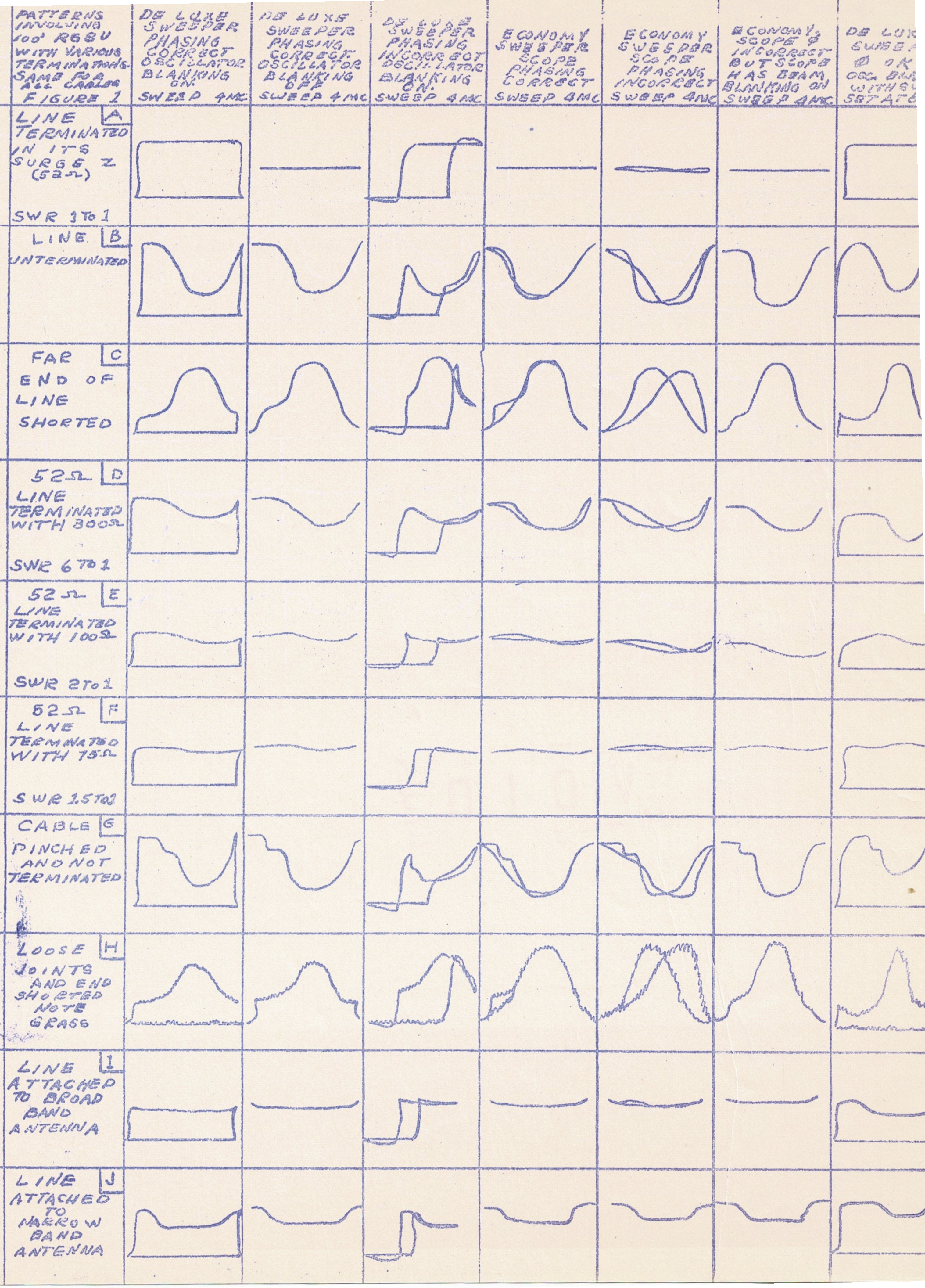
special shorting plug soldered within it. For 300 ohm line checking, bo covers are removed and a wire from each side of the 300 ohm line is con ected to each coax reeptacle.

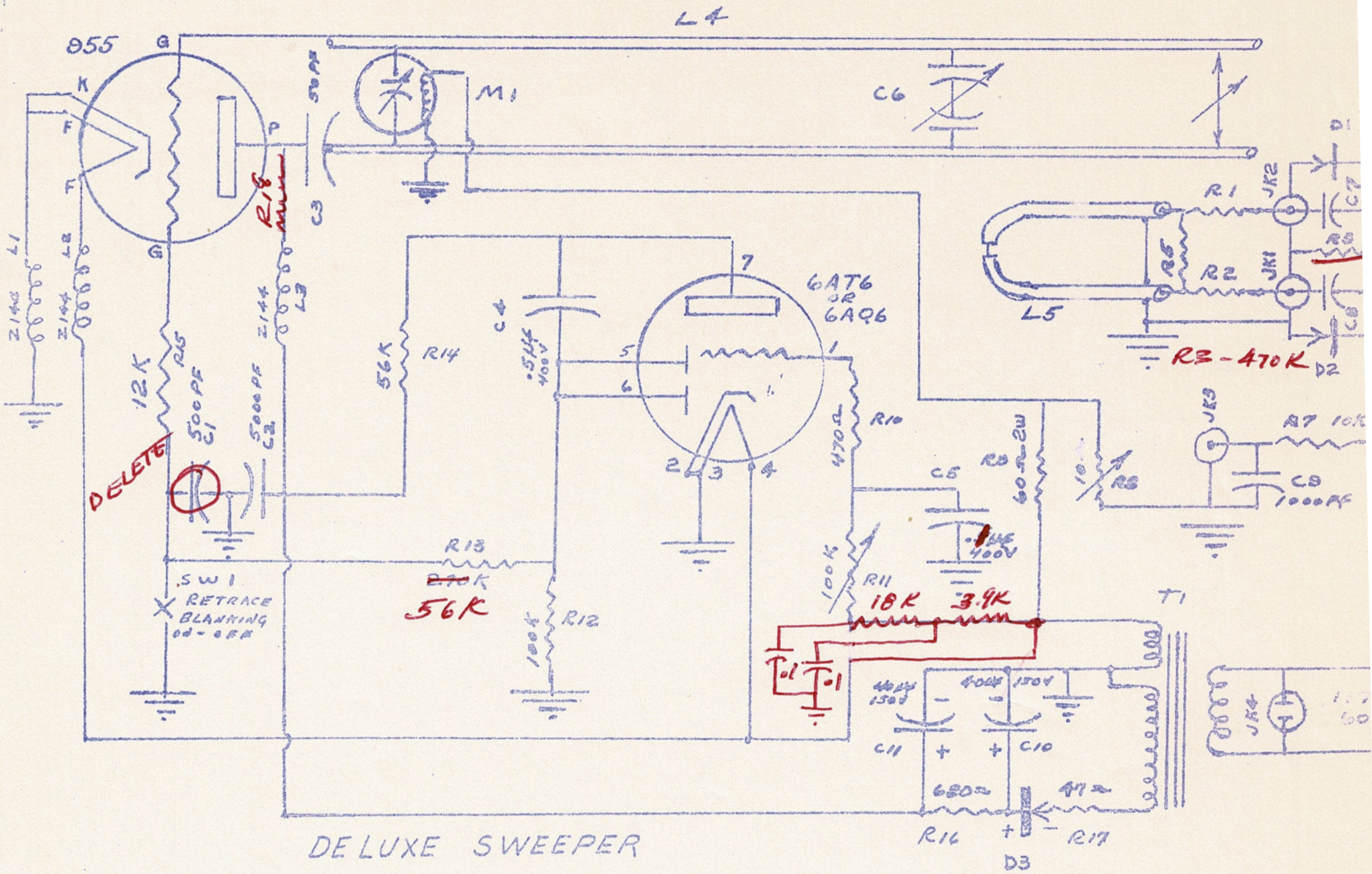
The sweeper has its own power supply within it and is isolated fro ground. A 117 volt receptacle is also included so as to have a place to plug in the scope. The scope need not be an elabarate one and need not have a high frequency response. 60 cycles is the highest frequency measured. The scope must have a sync system that can be coupled to the line for sync with the sweeper. 99% of scopes are so equipped.

The sweeper can be built in a box 3"by 5"by 10" or what have you. No attempt will be made here to indicate exact construction details. Th basic oscillator dimensions and circuit values will be given. So build in what you have and how you like to. The places where special care and short leads are an absolute necessity will be indicated. In building th sweeper see the mounting diagrams and drill or punch holes to fit the parts you are going to use. This also depends on which model you are going to build. Short leads are definitly required in the assembly of the diode detectors, coax connectors, load resistors and the pickup lin The construction of this portion is refered to in Fig. 3.

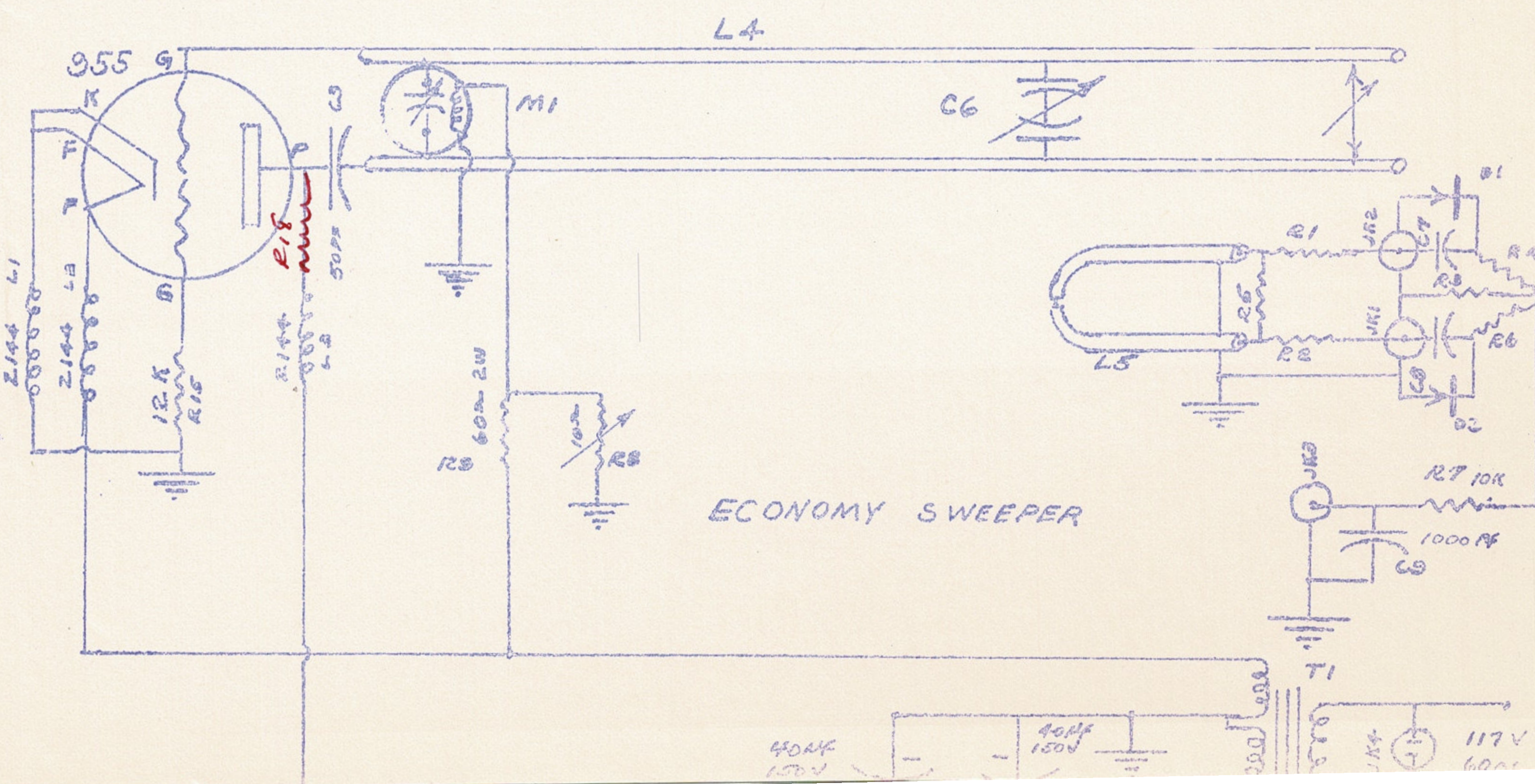
After the assembly has been completed, testing and calibrating mus be started. Set the variable capacitor to mid scale. Tune a 2 meter receiver to 146 MC. Turn sweep width control to zero. Tune the oscillat to 146MC by listening in the receiver and adjusting the shorting bar on the oscillator long lines. The dial is now centered in the 2 meter band and other points on the dial may be marked by listening for the oscilla in the calibrated receiver. From now on wherever you set the dial the sweeper will sweep on both sides of this spot. How far it sweeps depend on how far you advance the sweep width control. We usually leave it at center scale, or 4 MC sweep. After you start to use the sweeper and yo have your antenna as flat as you think you can possibly get it, turn th sweep width control to zero and listen for the signal in a calibrated

2 meter receiver. The frequency that the signal is picked up at is the center of the bandwidth of your antenna. If it is nat in the portion of the band that you use, you may want to readjust yuur matching device and possibly the length of your antenna elements to bring it on frequency. I have seen some antennas flat only outside the 2 meter band. It is obvio that more work on the antenna is necessary. To use the sweeper, attach th vertical amplifier of the scope through a shielded cable to the connectio for it on the sweeper. Set the time base to line frequency and sync the scope to 60 cycles. Some scopes have a built in source of 60 cycles. Thos that dont will have to couple the horizontal amplifier to about 6 volts 60 cycles as supplied by a small filament transformer. Set the sweep widt to 4 MC. Set the frequency dial to 146MC. Couple the antenna to be checke to the sweeper with at least 100 feet of cable to the coaxial receptacles desired. Be sure the shorting cover is on the unused receptacle. If 300 ohm line is used, take both covers off and connect one side of the 300 ohm line to each one. Be sure that the excess line is not coiled up, but is stretched out and away from all objects. It can be suspended on string during the test. Excess coax can be coiled up, but never ribbon or open line. Adjust the vertical gain of the scope so that the trace occupys about 2/3 of the screen height. If the vertical size of the trace is not great enough, your scope lacks vertical sensitivity. This can be correcte without to much inaccuracy, by completly removing R5, the oscillator output terminating resistor, or substituting a more sensitive scope. Advance the horizontal gain so that the trace occupys about 80% of the screen width. Refer to the diagrams of patterns obtainable and check your particular condition. You can determine if its scope adjusting, sweeper controls or antenna that has to be adjusted for correcte patterns. After the scope controls, height, phasing, blanking etc, and the sweeper contro are set ok then proceed with antenna adjustments. Adjust for a trace that indicates a SWR of 1 to 1 or as close as you can come to it.


PATTERNS INVOLVING 100' RG8U WITH VARIOUS TERMINATIONS. SAME FOR ALL CABLES
FIGURE 1
DE LUXE SWEEPER PHASING CORRECT OSCILLATOR BLANKING ON. SWEEP 4MC
DE LUXE SWEEPER PHASING CORRECT. OSCILLATOR BLANKING OFF SWEEP 4MC
DE LUXE SWEEPER PHASING INCORRECT OSCILLATOR BLANKING ON. SWEEP 4MC
ECONOMY SWEEPER SCOPE PHASING CORRECT SWEEP 4MC
ECONOMY SWEEPER SCOPE PHASING INCORRECT SWEEP 4MC
ECONOMY, SCOPE Ø INCORRECT BUT SCOPE HAS BEAM BLANKING ON SWEEP 4MC
DE LUX SWEEP Ø OK OSC. BL WITH SW SET AT 6
A
LINE TERMINATED IN ITS SURGE Z (52Ω)
SWR 1 TO 1
B
LINE UNTERMINATED
C
FAR END OF LINE SHORTED
D
52Ω LINE TERMINATED WITH 300Ω
SWR 6 TO 1
E
52Ω LINE TERMINATED WITH 100Ω
SWR 2 TO 1
F
52Ω LINE TERMINATED WITH 75Ω
SWR 1.5 TO 1
G
CABLE PINCHED AND NOT TERMINATED
H
LOOSE JOINTS AND END SHORTED NOTE GRASS
I
LINE ATTACHED TO BROAD BAND ANTENNA
J
LINE ATTACHED TO NARROW BAND ANTENNA



DELUXE SWEEPER



ECONOMY SWEEPER

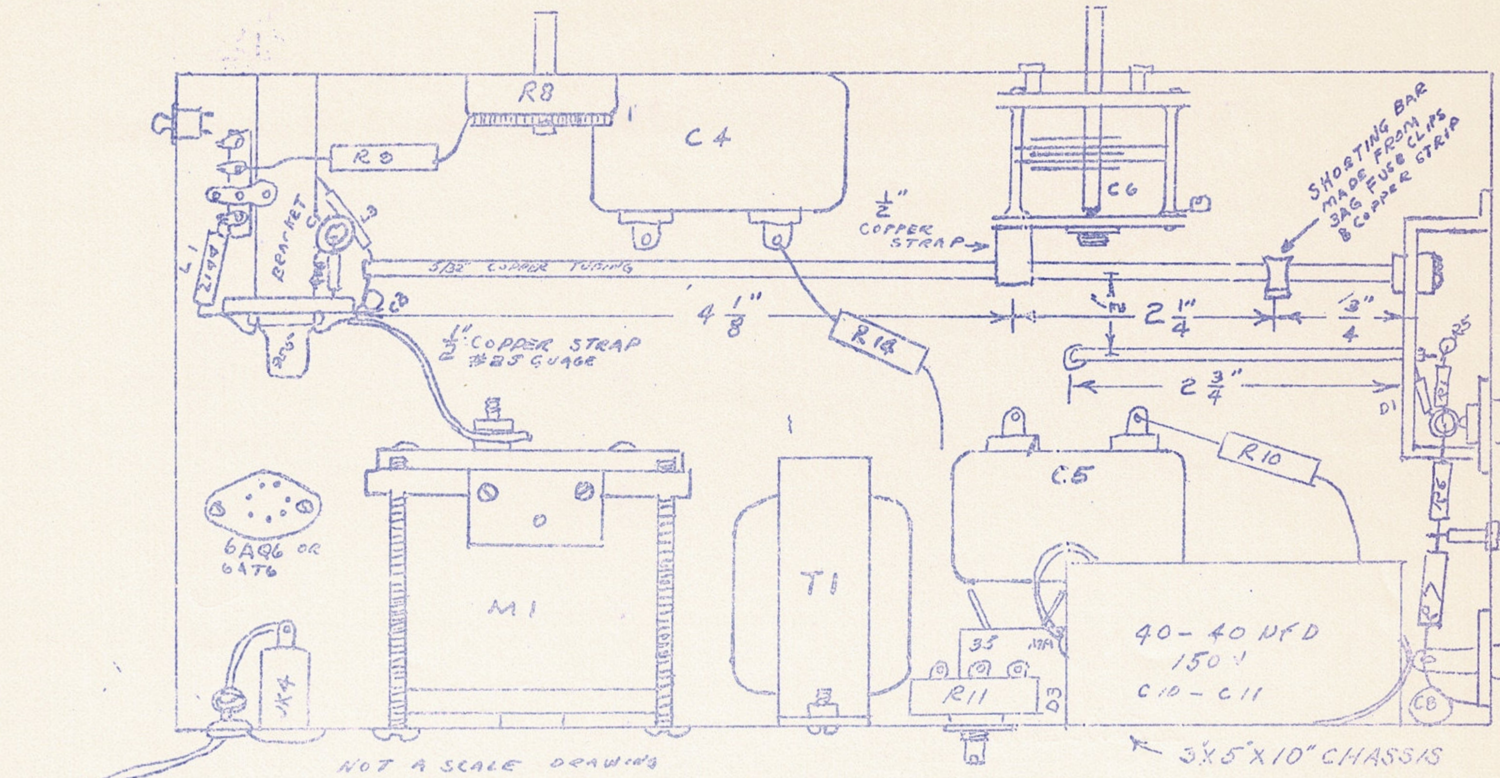


FIG.3A

SUGGESTED LAYOUT

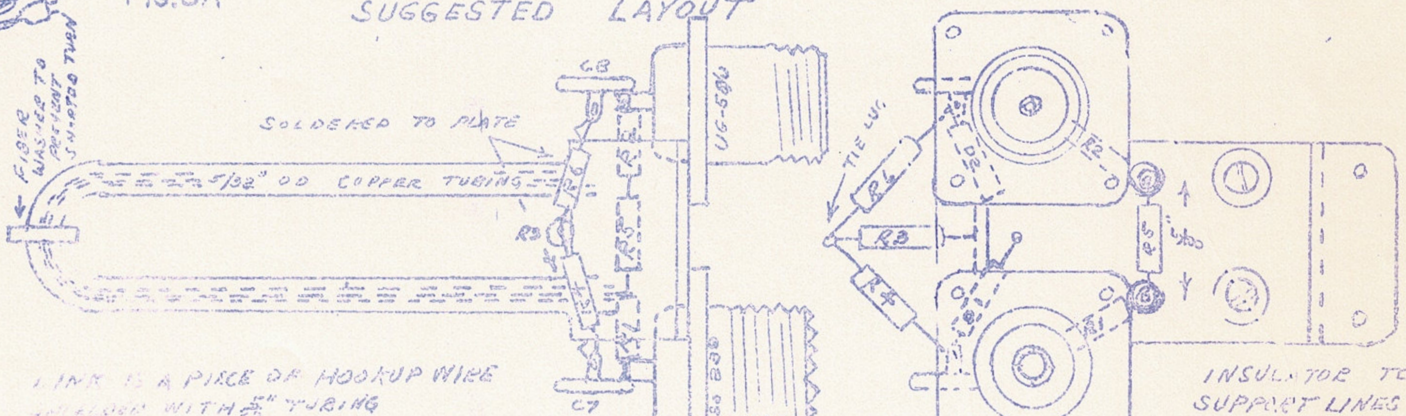


FIG.3B

LINK ASSEMBLY

FULL SCALE

FOR UG-58/U

COAX. CAPS
MODIFIED TO SHORT CIRCUIT
FULL SCALE

FOR SO 239

FIG.3C

Other uses for the "Sweeper".

Checking the input impedance of receivers.

Checking the output impedance of noise generators.

Finding the impedance of unmarked cables.

Determine if the cable has a kink or some other discontinuety.

Transmission line which has a flaw, such as a pinch or partly open outer shield will cause a discontinuety to appear on the scope pattern as shown in Fig 1 E.

Aids in search for correct values of dummy loads for testing transmitters.

Location of noisy connections in transmission lines.

Noisy connections will show up as grass on the otherwise smooth standing wave trace and its base line.

PARTS LIST

R1, R2, R5, 100 ohm 1/2 W 5% Carbon	~~C1, 500 PF~~ Ceramic Capacitor
R3, ~~100~~K 470K " " "10% "	C2, 5000 PF " "
R4, R6, R7, 10K " " " " "	C3, 50 PF Silver Mica Button "
R8, 10 ohm WW Rheostat 5W	C4, [illegible] 0.5 MFD. 400V Paper "
R9, 60 " 2W WW or Carbon	C6, Butterfly 5 plate from SCR522 "
R10, 470 " 1/2W 10% Carbon	C7, C8, 500PF Silv. Mica Buttom "
R11, 100K Potentiometer	C9, 1000 PF Ceramic "
R12, 100K ohm 1/2W 10% Carbon	C10, C11, 40-40 MFD 150V Elect. "
R13, ~~270K~~ 56K 1/2W " "	D1, D2, 1N64 or CK710 Diode
R14, 56K " 1/2W " "	D3, 35MA Selenfium Rectifier
R15, 12K " 1/2W " "	JK1 SO239 Coax Panel Receplacle
R16, 680 " 2W " "	JK2 UG-58/U " " "
R17, 47 " 1/2W " "	JK3 Phono Jack-CHinch
L1, L2, L3, Z144 RF Choke	M1 Sweep Capacitor-Motor assy. from APN
L4, L5, See Diagram	T1 Power Trans. 6.3V, 1Amp. 100V, 35MA 117V Pri. as used in TV boosters etc
R18 6.8K 1/2W	C5 3X.1 MFD 400V

The necessity of zero lead lengths on load resistors and the coax lead to them is made evident by this test.

* Sams PF INDEX #36 Jan 1953 P93
Radio News Sept. 1949 P52

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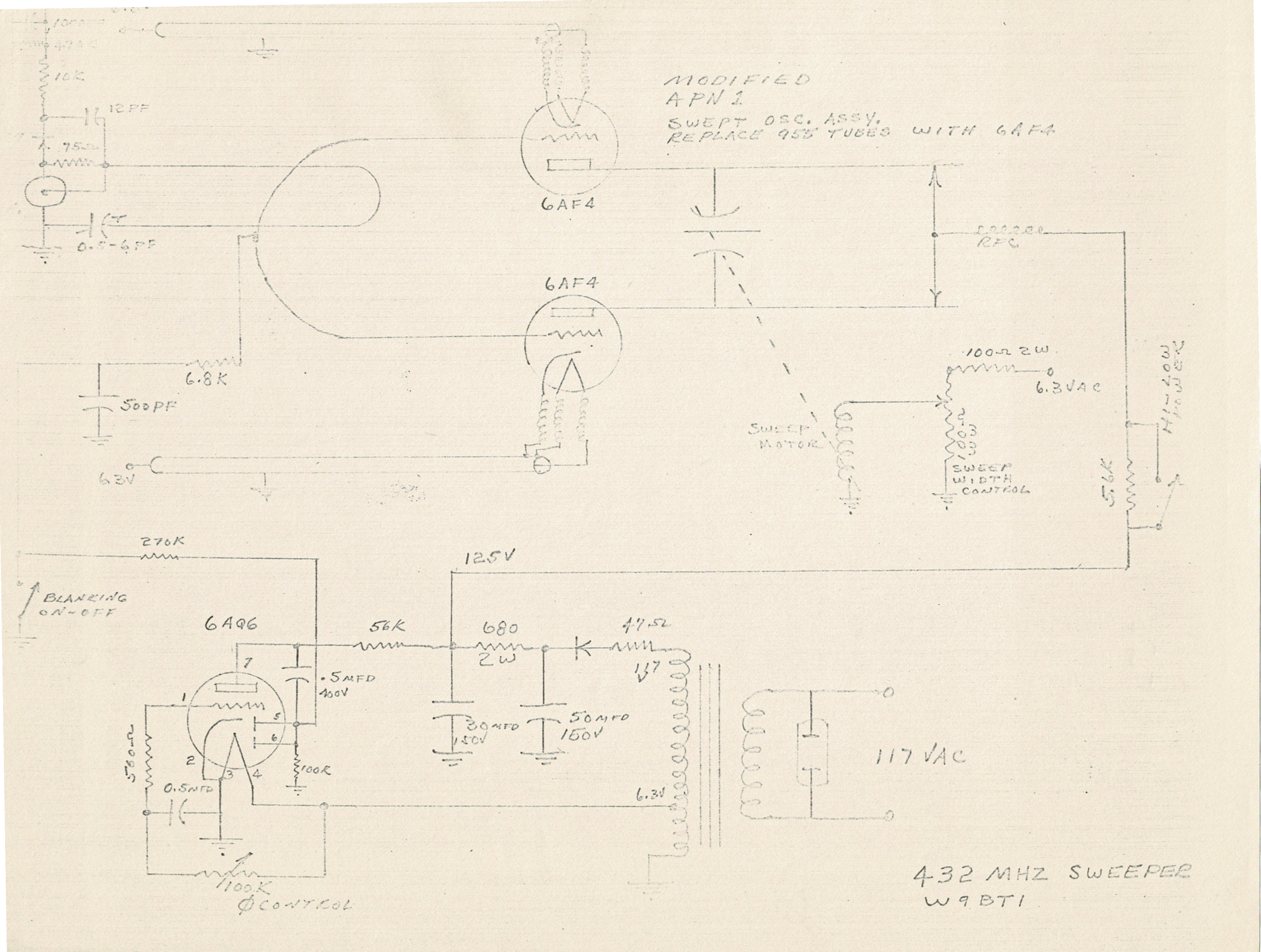

432 MHZ SWEEPER
W9BTI